Satellite data used in the New European Wind Atlas

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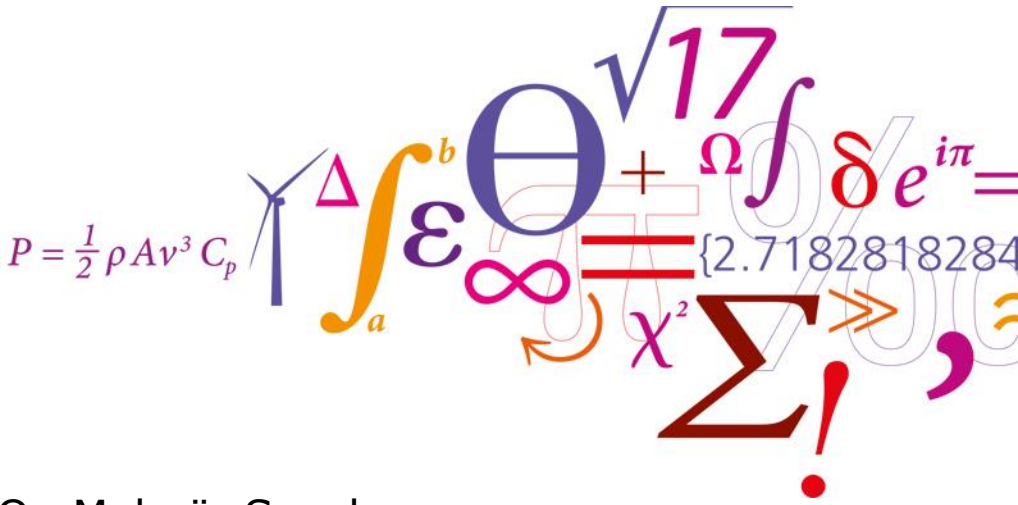


VindkraftNet 29 November 2016, E.On Malmö, Sweden

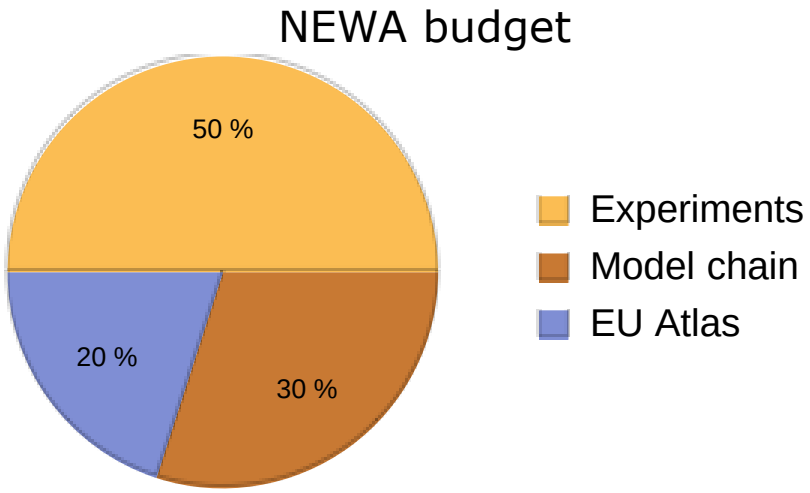
DTU Wind Energy
Department of Wind Energy

Content

- ✓ New European Wind Atlas (NEWA)
- ✓ Satellite data
  - Objectives
  - Synthetic Aperture Radar
  - Scatterometer
  - Passive microwave
- ✓ First results
- ✓ Conclusion

Purpose and structure of NEWA

- Accurate mapping of wind conditions for the estimations of resources and loads
- Development and testing of the model chain
- A series of atmospheric field experiment to validate the model and atlas.



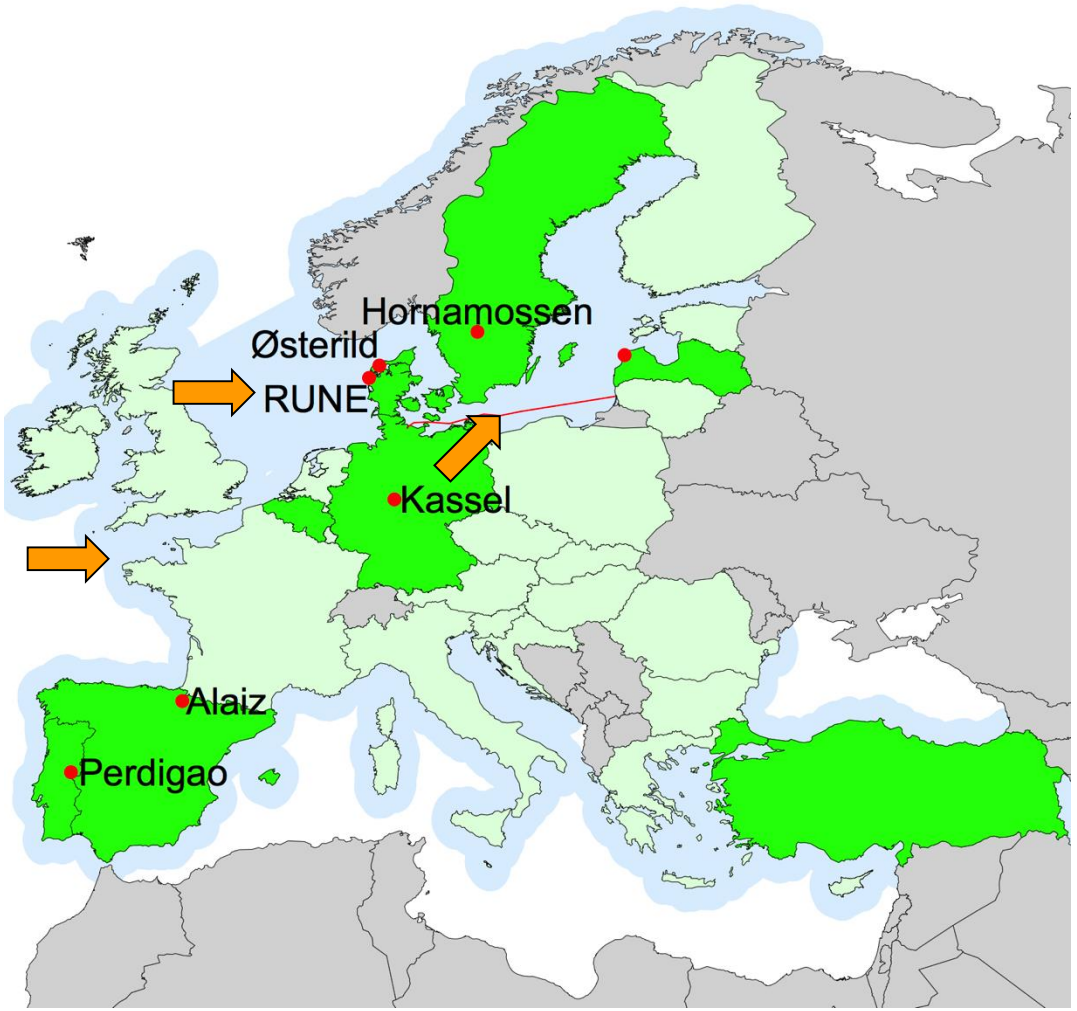
9 national funding agencies from
8 countries
30 partners

http://www.neweuropeanwindatlas.eu/

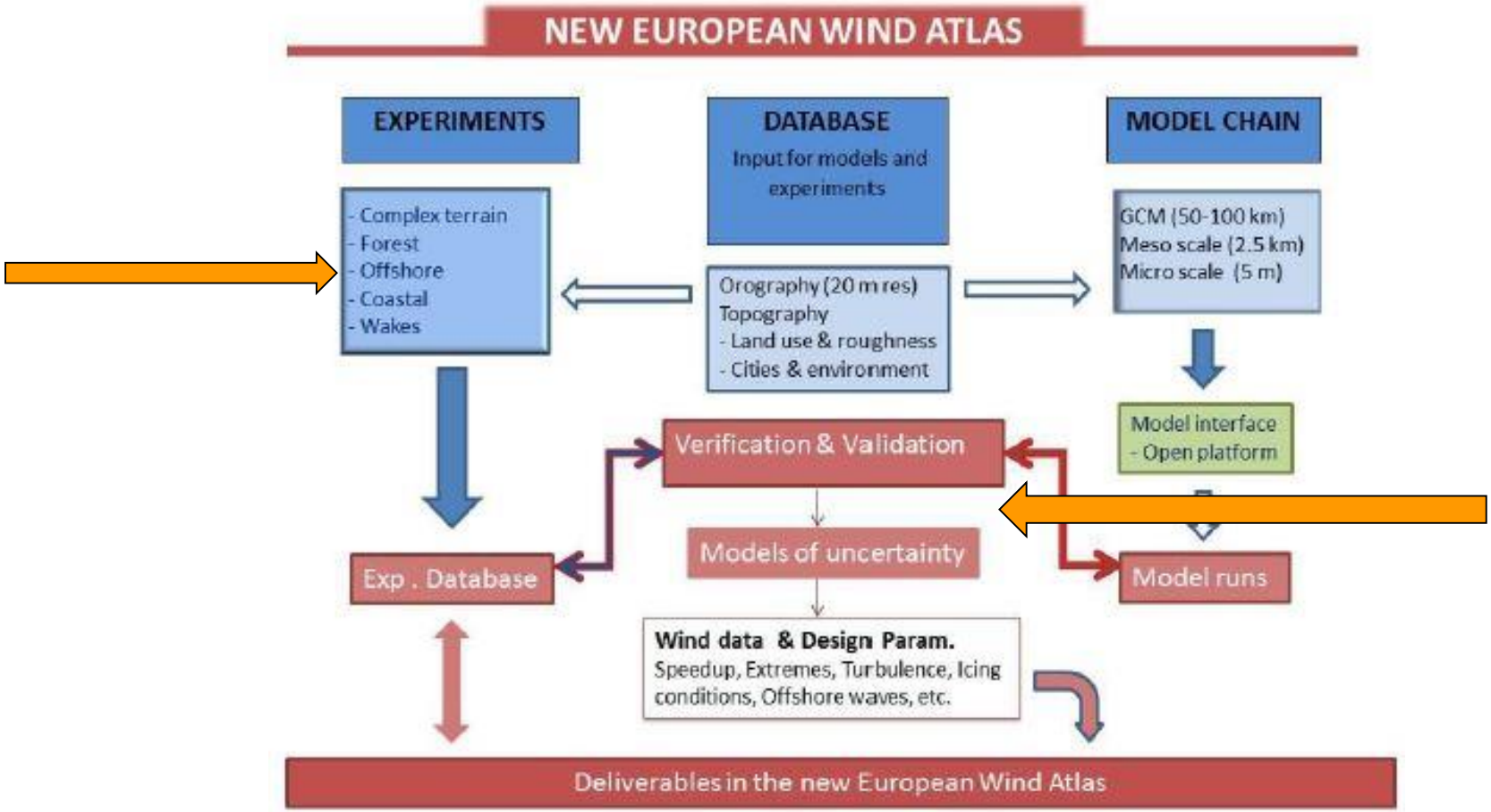
Years 2015 to 2020 ERA NET+

Experiments in the New European Wind Atlas

- EU countries
- **NEWA partners**
- Offshore coverage
- **Experimental sites**



New European Wind Atlas



Satellite data

Satellite data:
Objectives for NEWA *offshore* wind atlas

- ENVISAT ASAR data archive to cover all of Europe
- Sentinel-1 data to cover all of Europe
- Validate Sentinel-1 wind fields
- Merge ENVISAT ASAR and Sentinel-1 to a complete SAR wind atlas

- Possibly integrate with NEWA's modeling chain:
  - higher-resolution model wind directions as input
  - lifting of satellite winds beyond 10 m

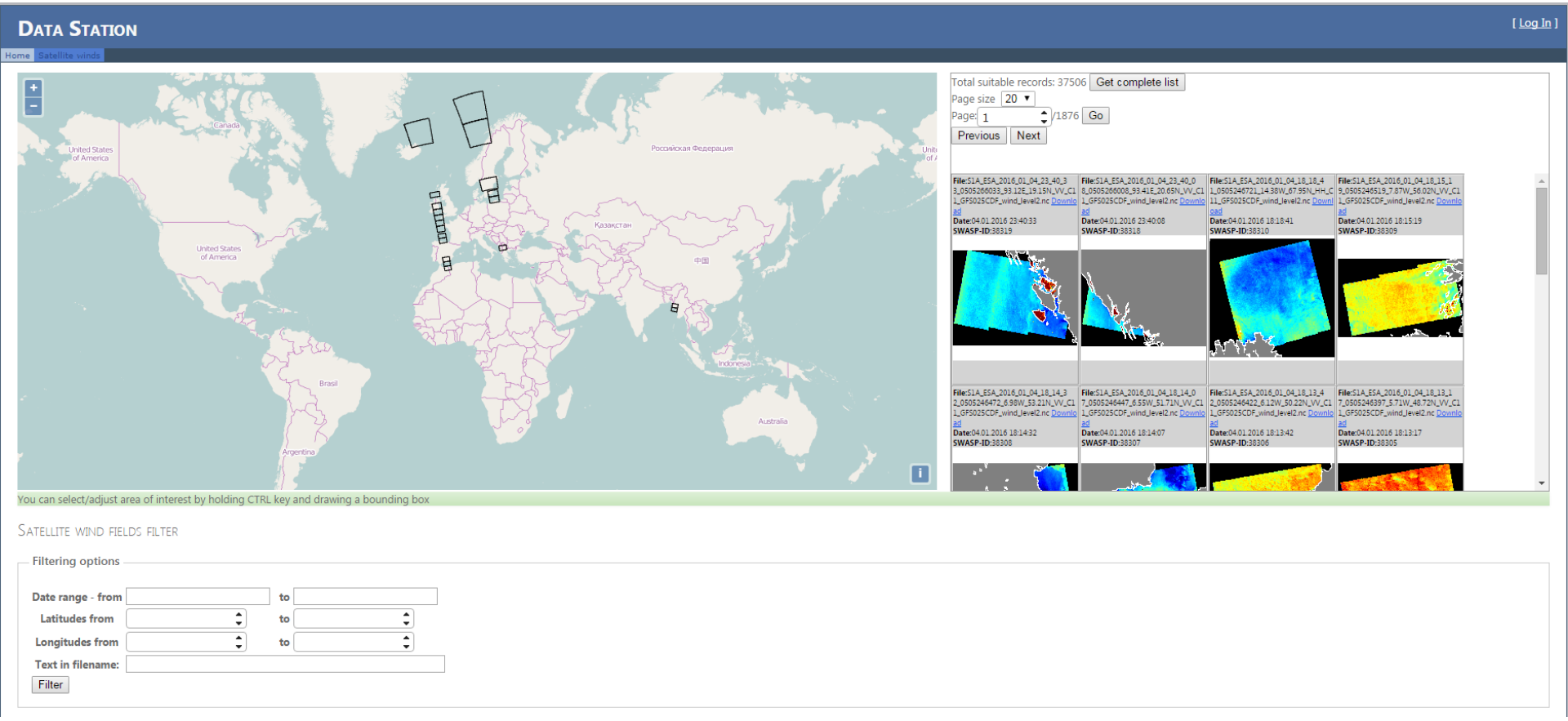
- Use ASCAT wind statistics for comparison to models
- Use SSM/I wind statistics for comparison to models

- Compare satellite data to ship lidar data

- Sea surface temperature input to models

SAR wind data archive at DTU

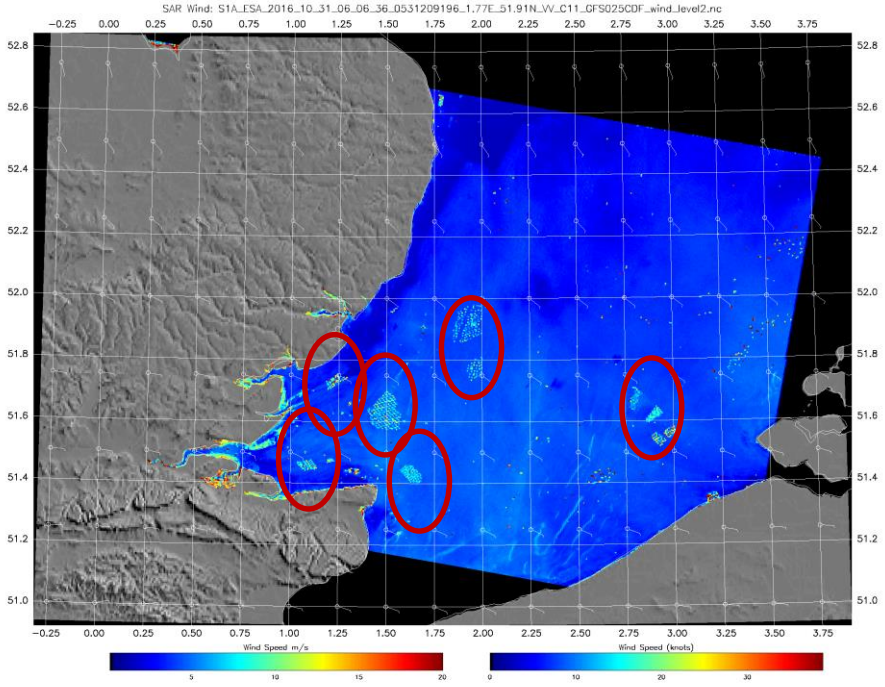
- 30,000+ ENVISAT ASAR scenes (2002-2011)
- 36,000+ Sentinel-1 A/B SAR scenes (2014->)



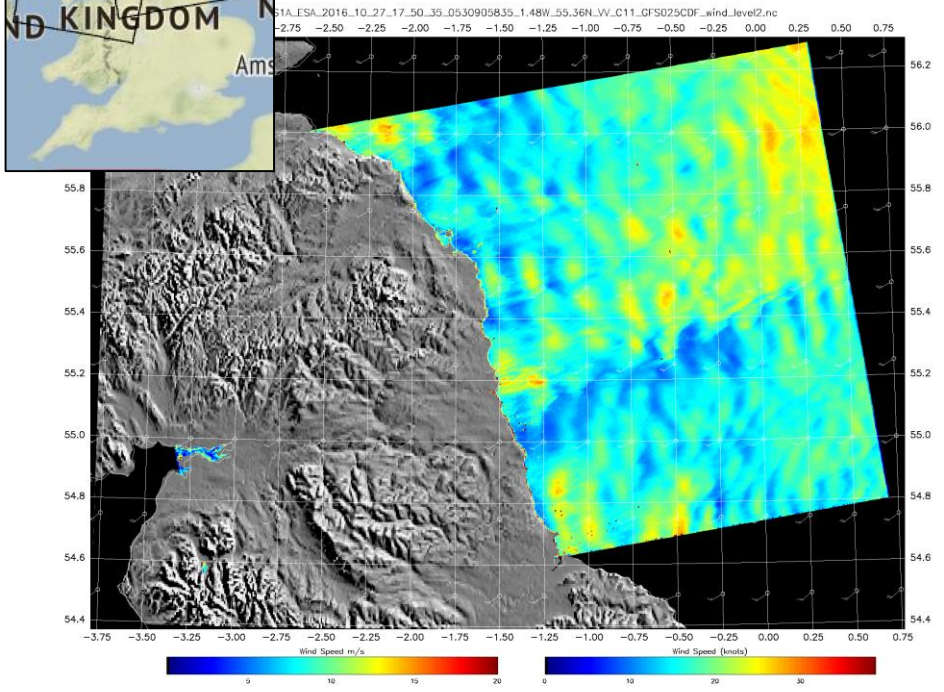
SAR Ocean Products System (SAROPS)

- Evolved from the APL/NOAA SAR Wind Retrieval System http://fermi.jhuapl.edu/
- SAR wind retrieval in near-real-time
- DTU covers the European seas (routine)
- Merete Badger operates SAROPS at DTU

Sentinel-1 over the UK



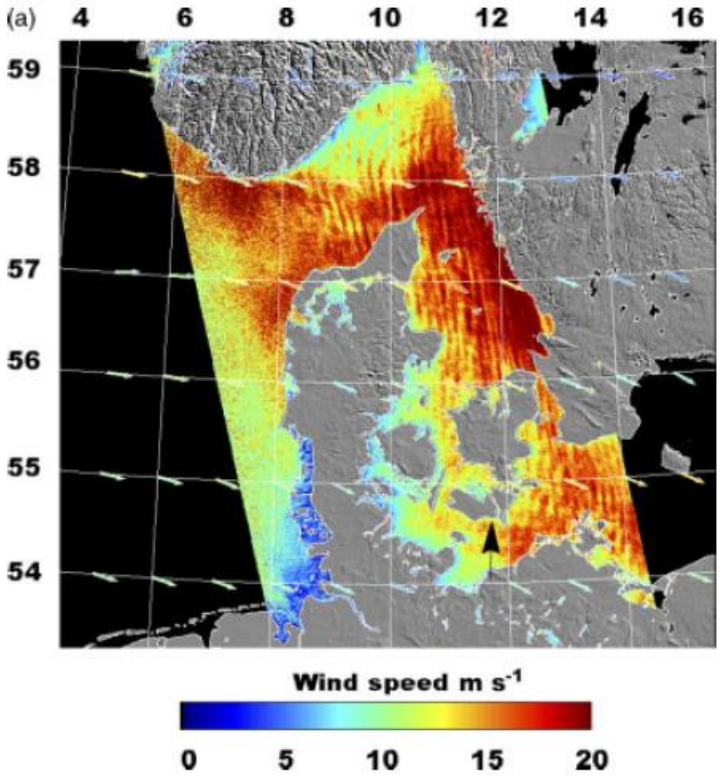
October 31, 2016 at 06:06 UTC



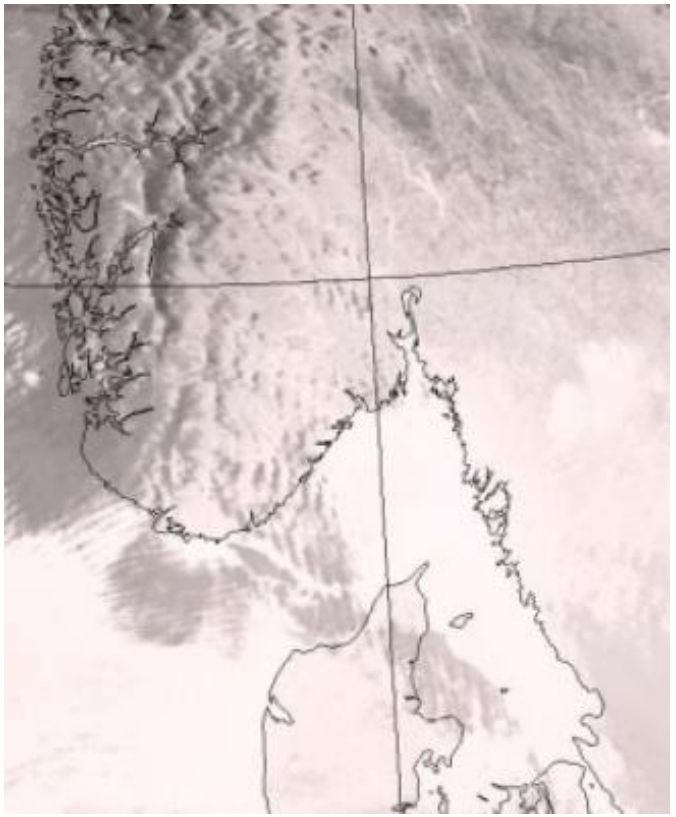
October 27, 2016 at 17:50 UTC

Mountain gravity waves

November 6, 2006

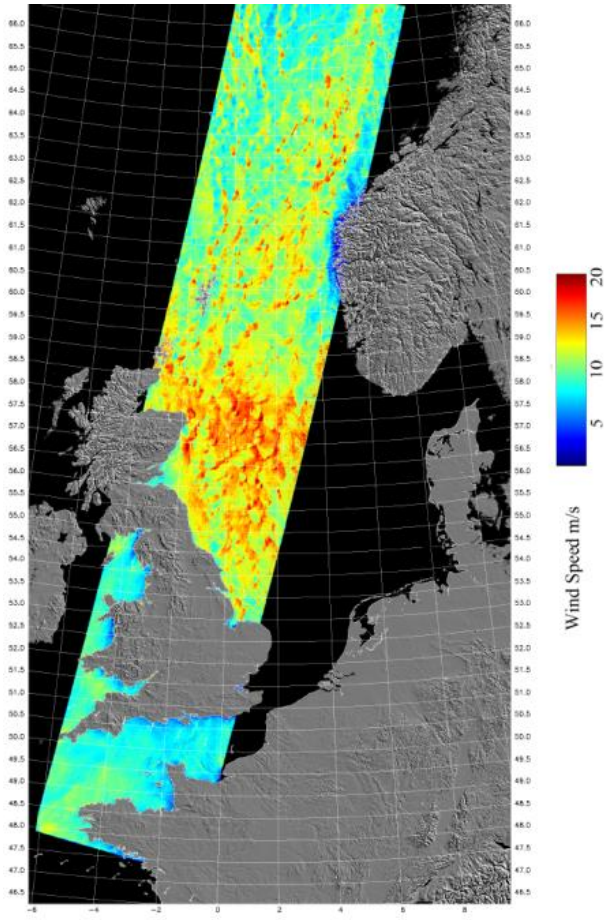


Envisat ASAR 10-m wind speed

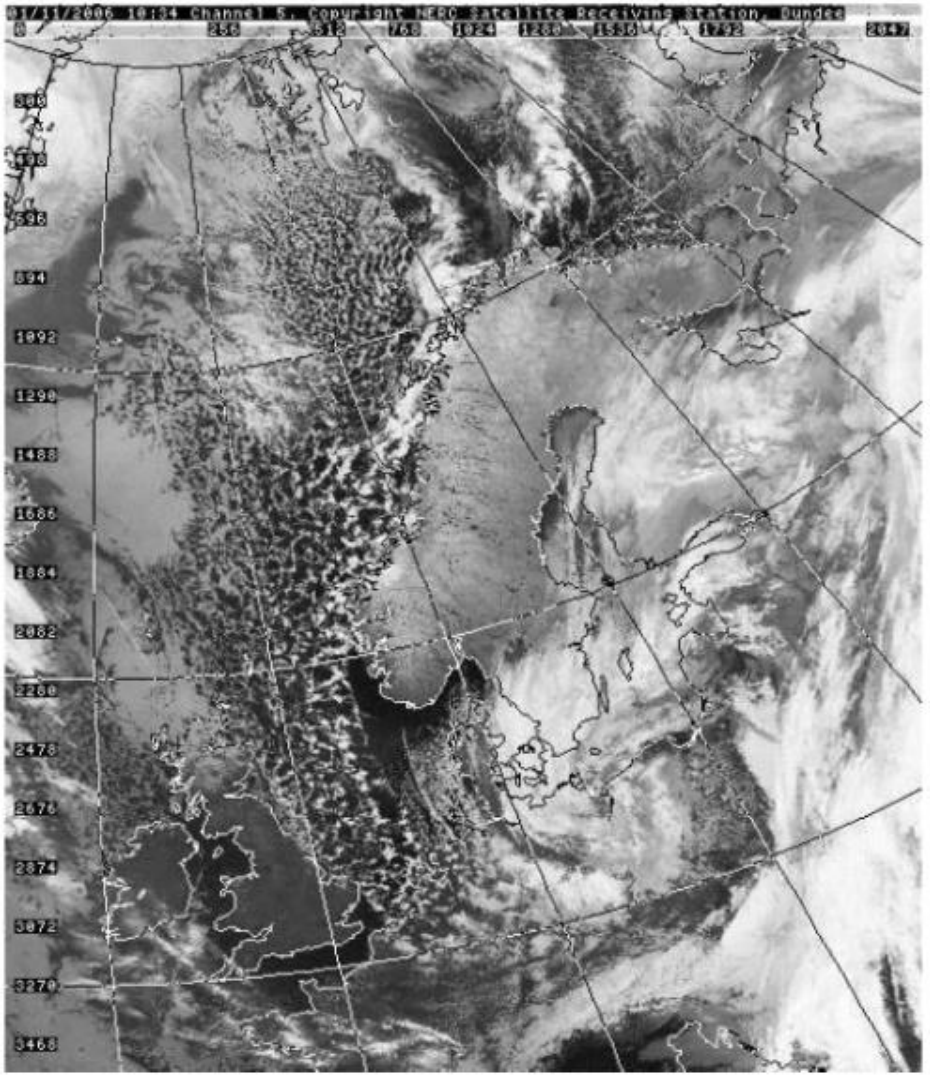


Cloud image

Open cells

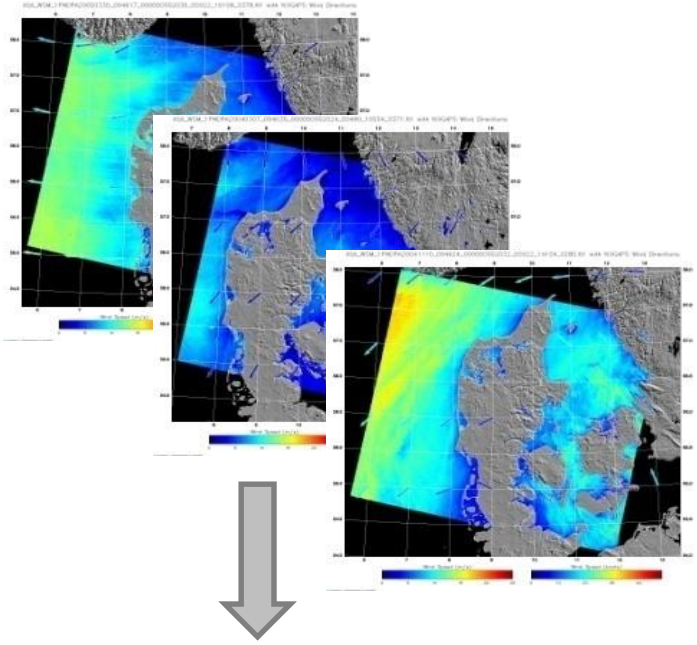


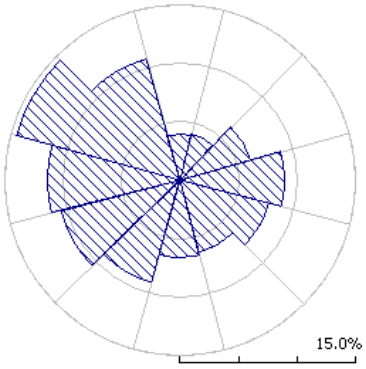
Envisat ASAR 10-m wind speed

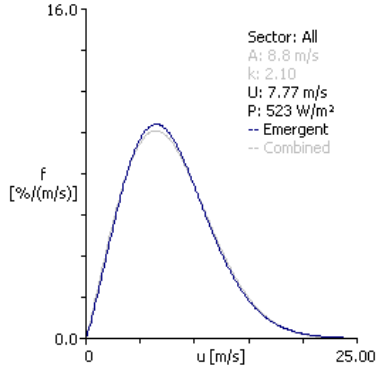


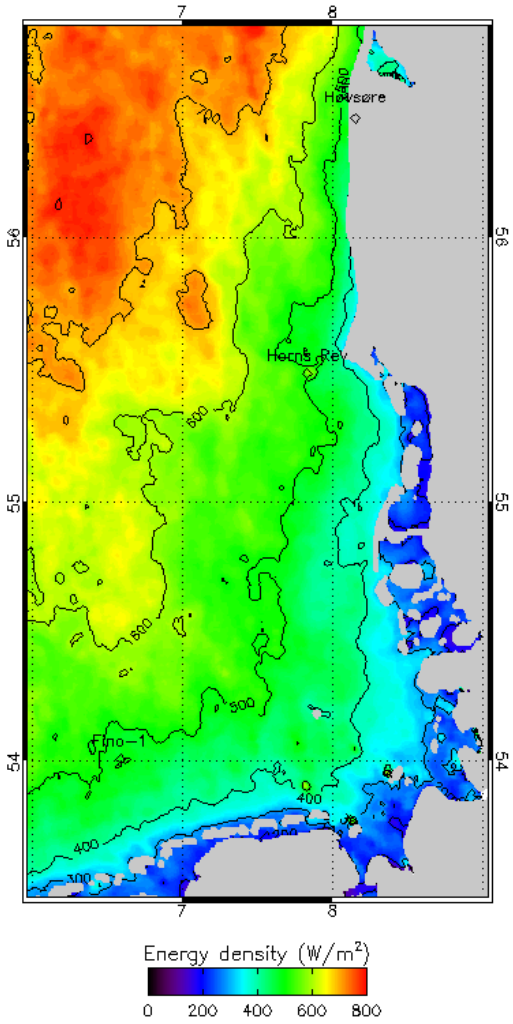
Cloud image

Wind resource mapping

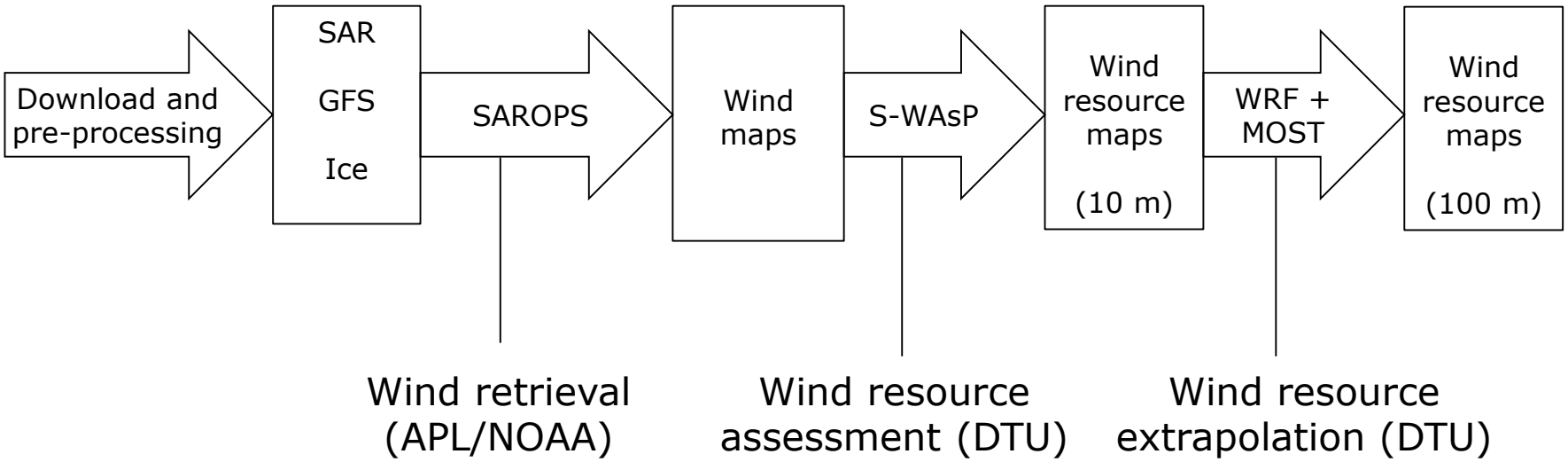






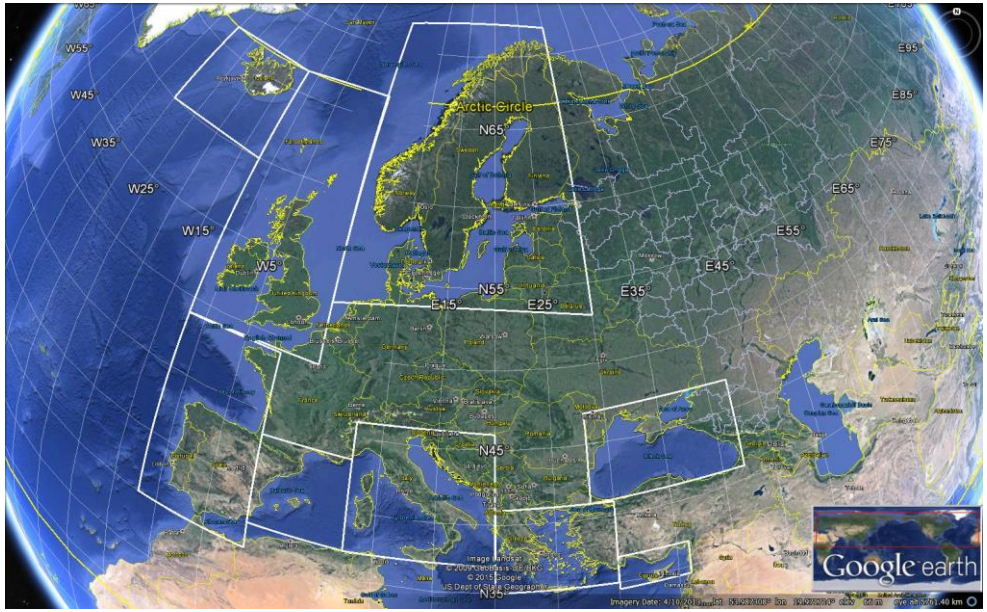


Chain of processes



The New European Wind Atlas (NEWA)

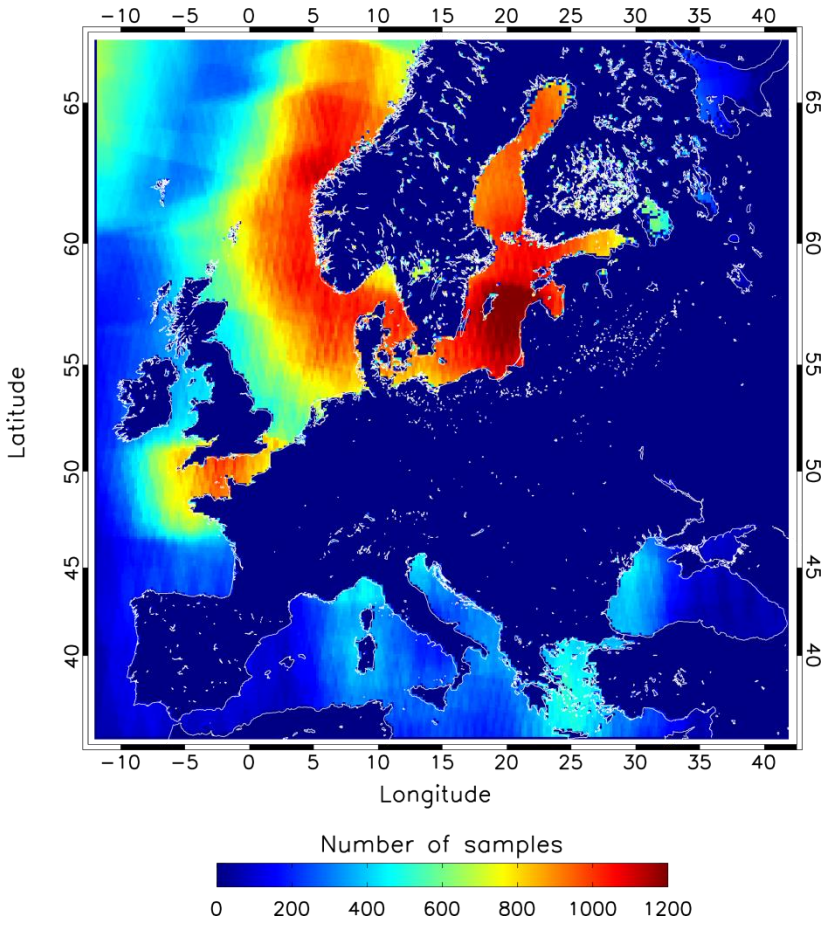
- Envisat ASAR and Sentinel-1 A/B
- Extrapolation to different heights up to 100 m
- Extensive measurement campaigns and modeling

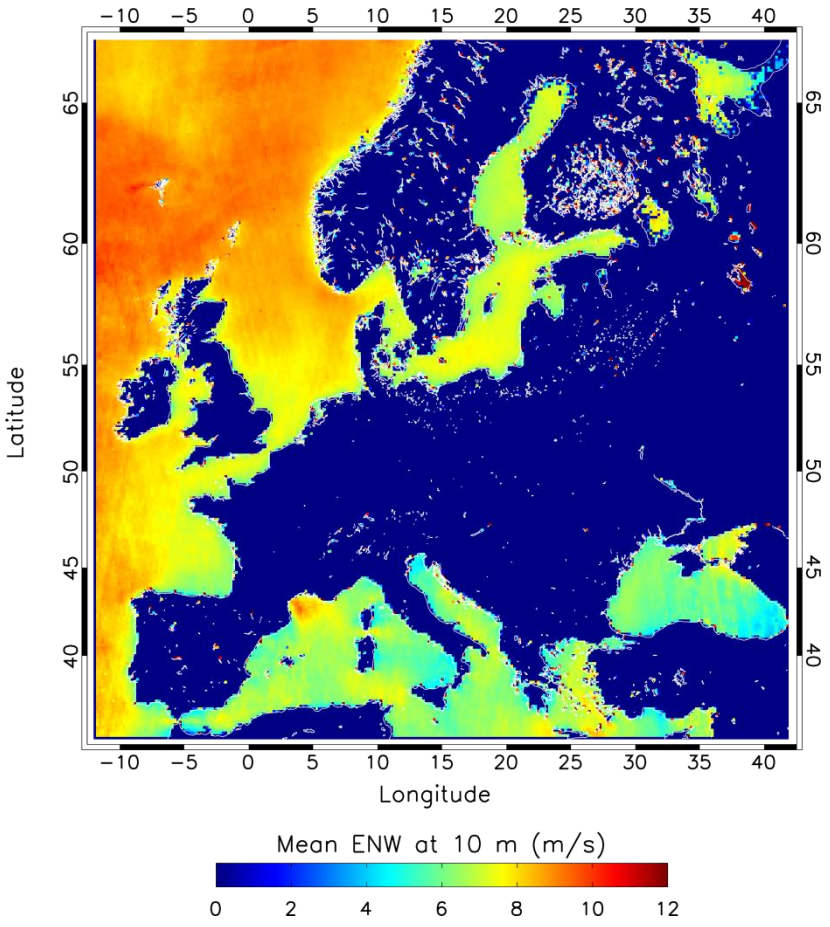


Coverage of the satellite based atlas in NEWA

(image courtesy Google Earth)

Preliminary 10-m atlas for Europe

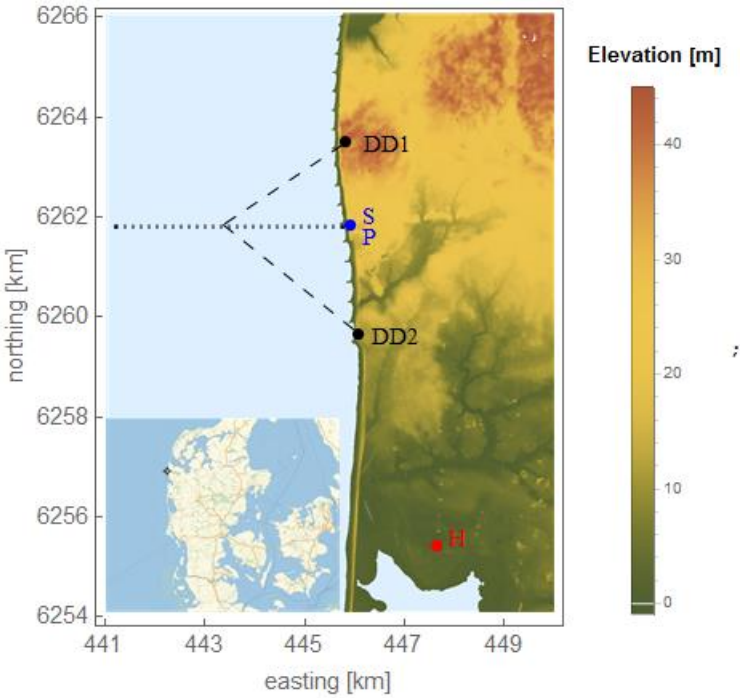




Envisat ASAR and Sentinel-1A/B combined

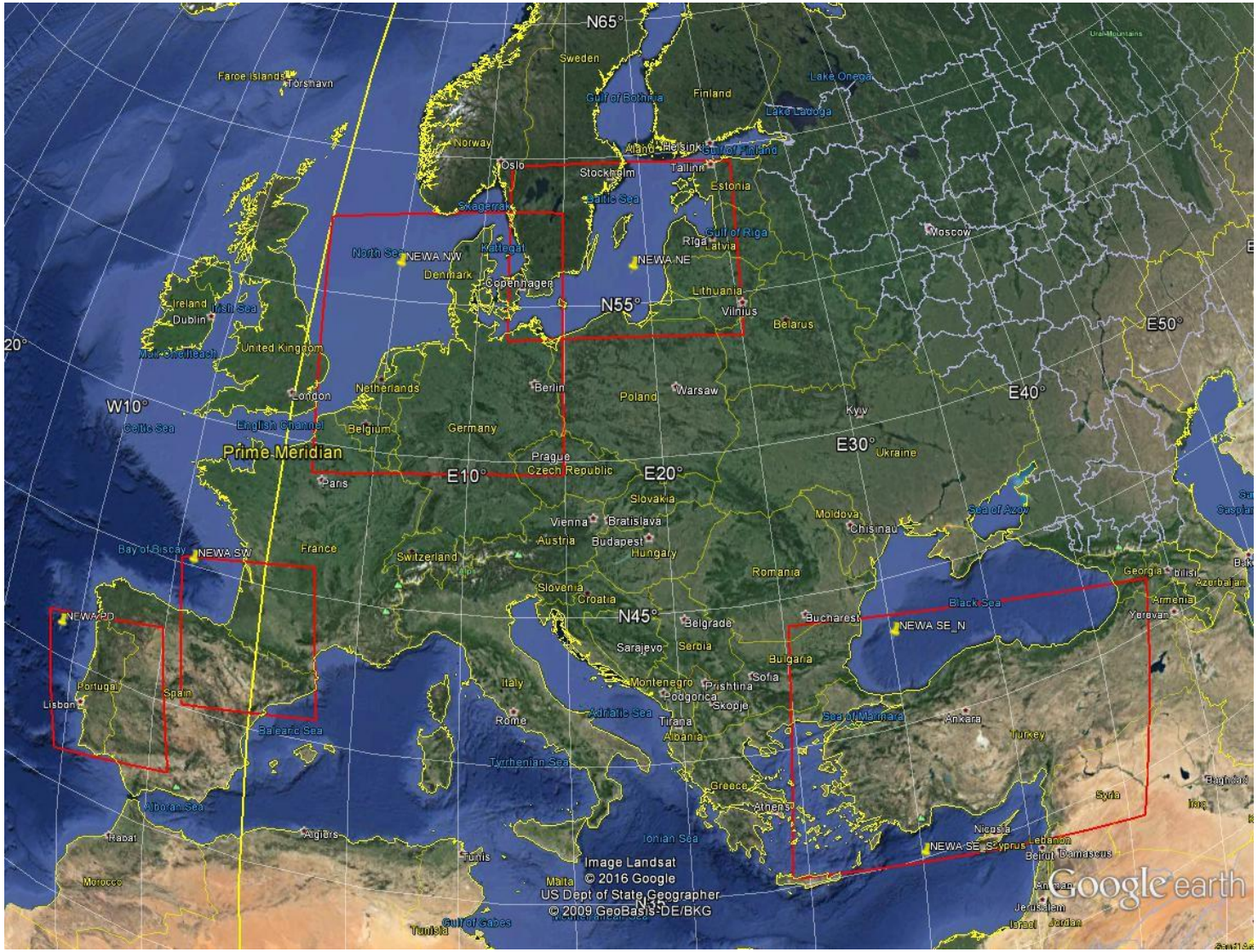
SAR for coastal applications (RUNE)

DD) Scanning lidars for dual Doppler scan
S) Scanning lidar for PPI scans
P) Profiling lidar,
H) Høvsøre met mast
Dotted line) Transect for lidar and SAR measurements



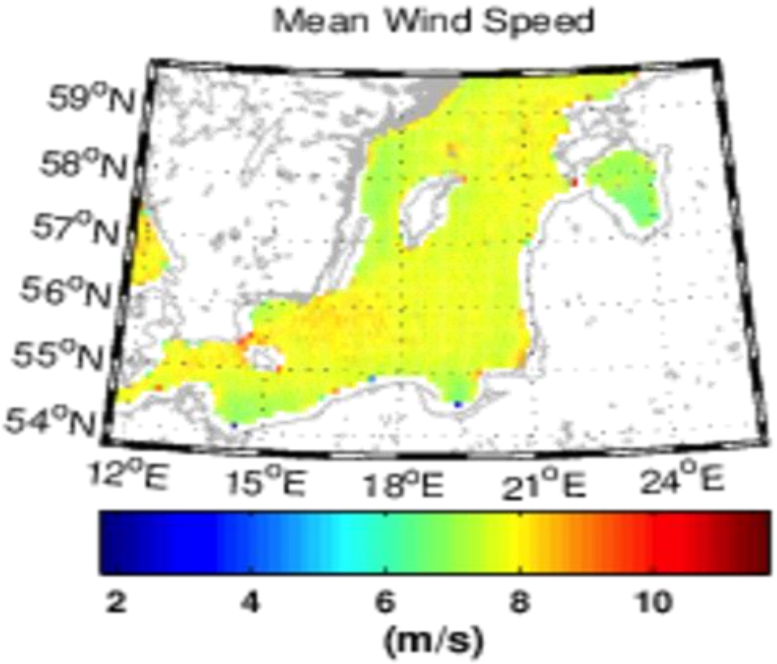
Scatterometer: ASCAT

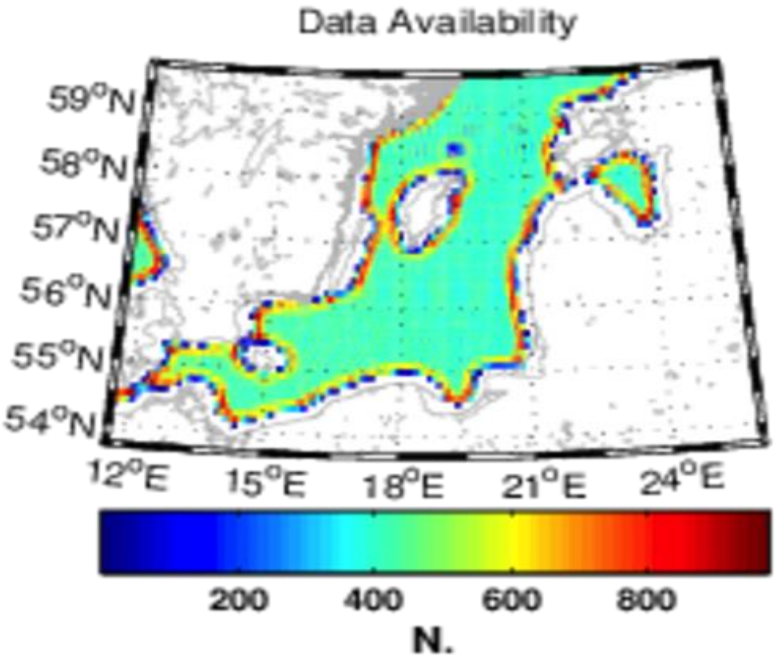
ASCAT data analysis



ASCAT Winds

- ASCAT 12.5 coastal product (swath)
- 2015 data
- Wind speed and direction statistics

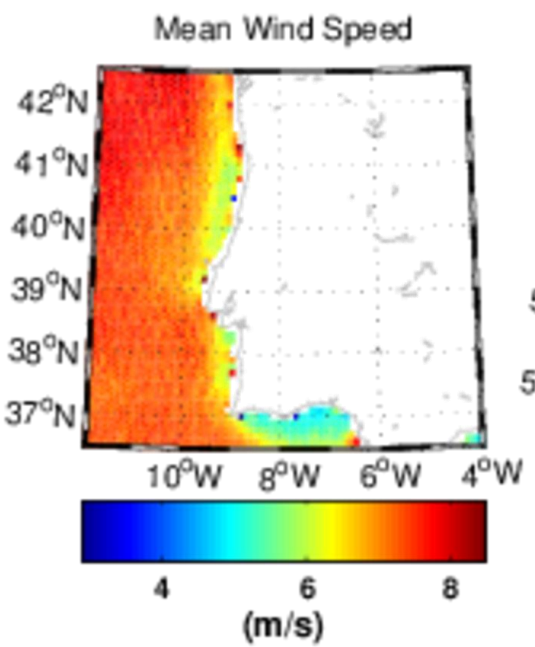


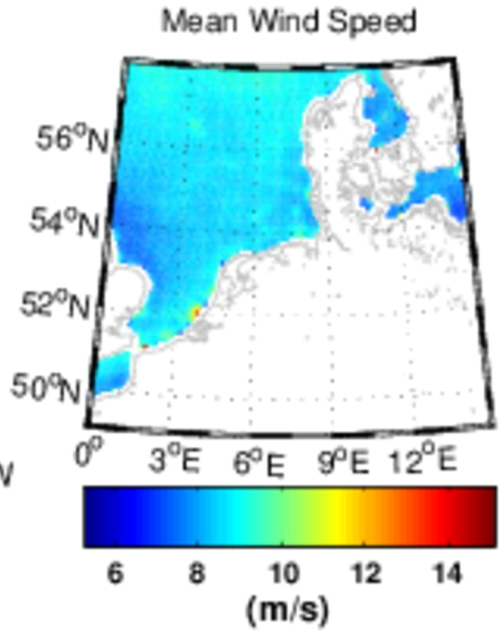


Domains: Perdigão NorthWest

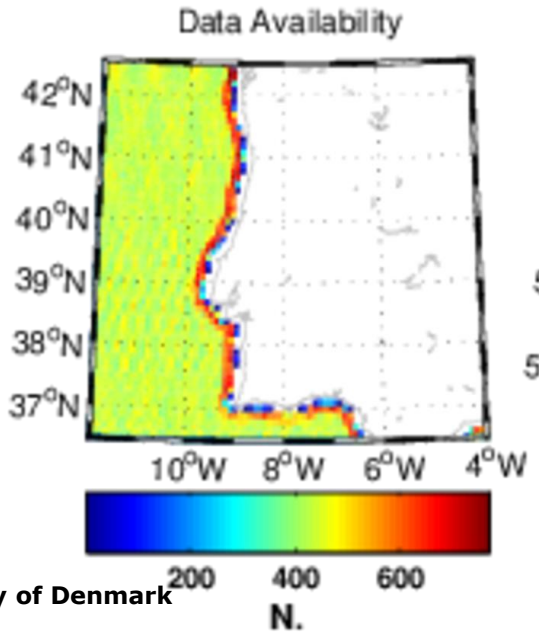
ASCAT

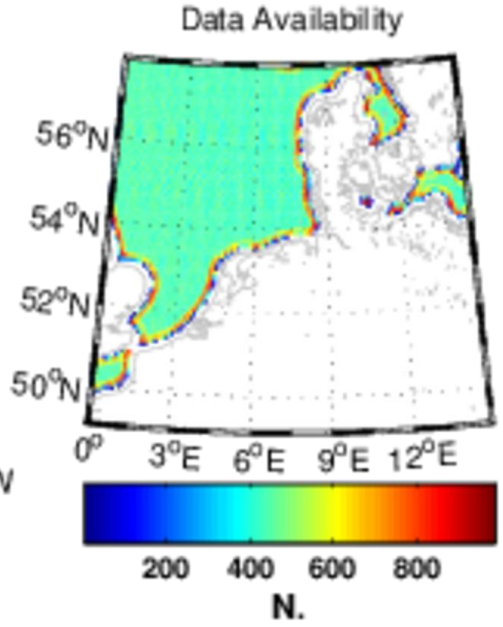
Mean wind speed at 10m





Data availability

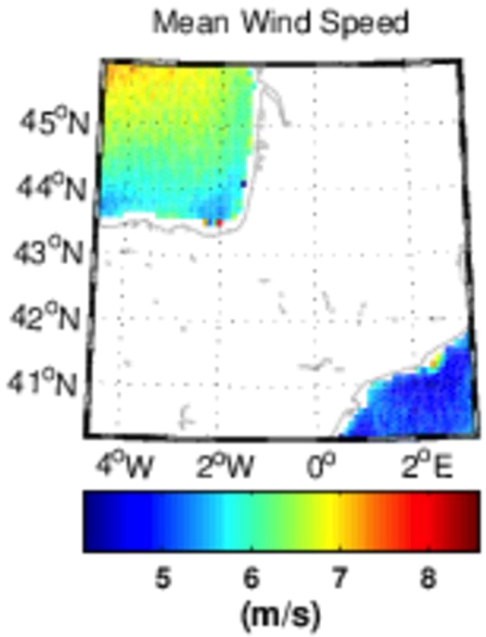


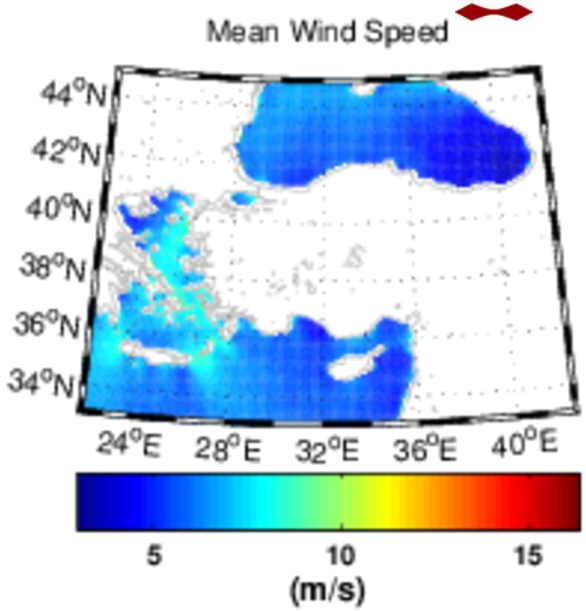


Domains: SouthEast SouthWest

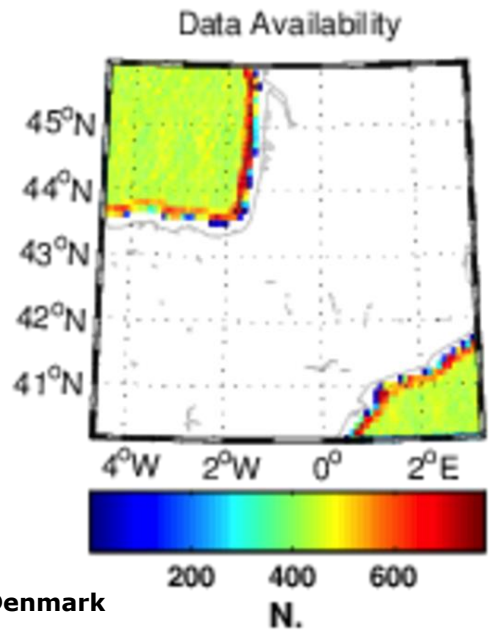
ASCAT

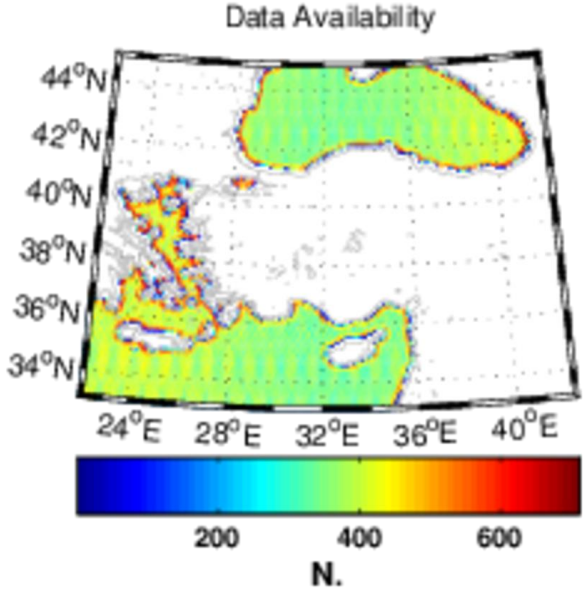
Mean wind speed at 10m





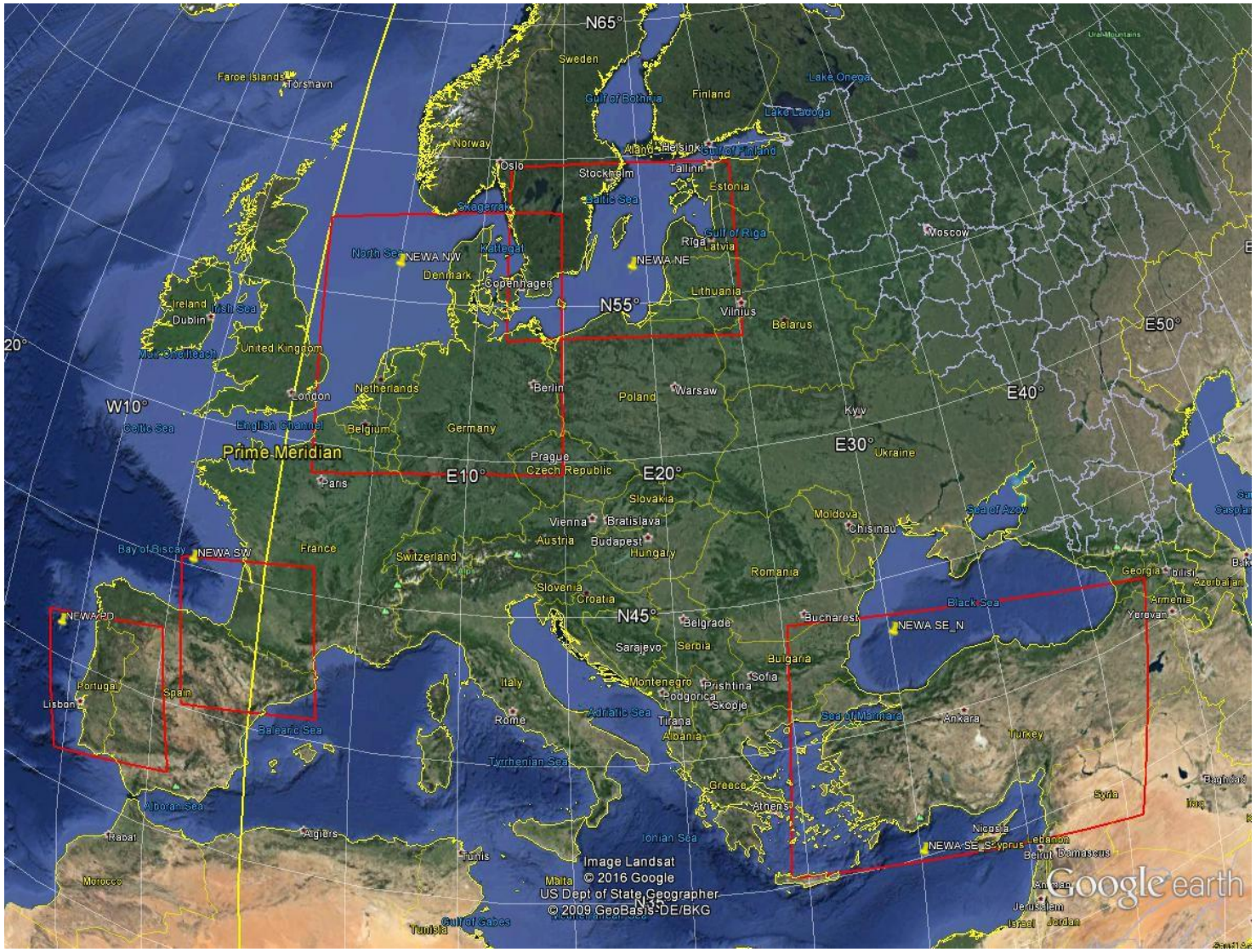
Data availability





Passive microwave: SSM/I

SSM/I data analysis



SSM/I and WRF key information

Wind speed analysis based on SSM/I version 7 data from satellites F8, F10, F11, F13, F14, F15, F16, and F17.

The SSM/I point data are each an average of the values of the four surrounding 0.25*0.25 degree pixels.

WRF from DTU Wind Energy calculations with 10 km grid spacing and output at 1 hour time resolution. WRF data are those from the nearest WRF grid point. This WRF run is not part of NEWA but a preliminary run done for another purpose: WRF: Andrea Hahmann and Patrick Volker.

All for the time interval 1st January 1988 to 31st December 2015. This means 28 full years.

All data are for 10 m above ground.

Poul Astrup has compared SSM/I and WRF.

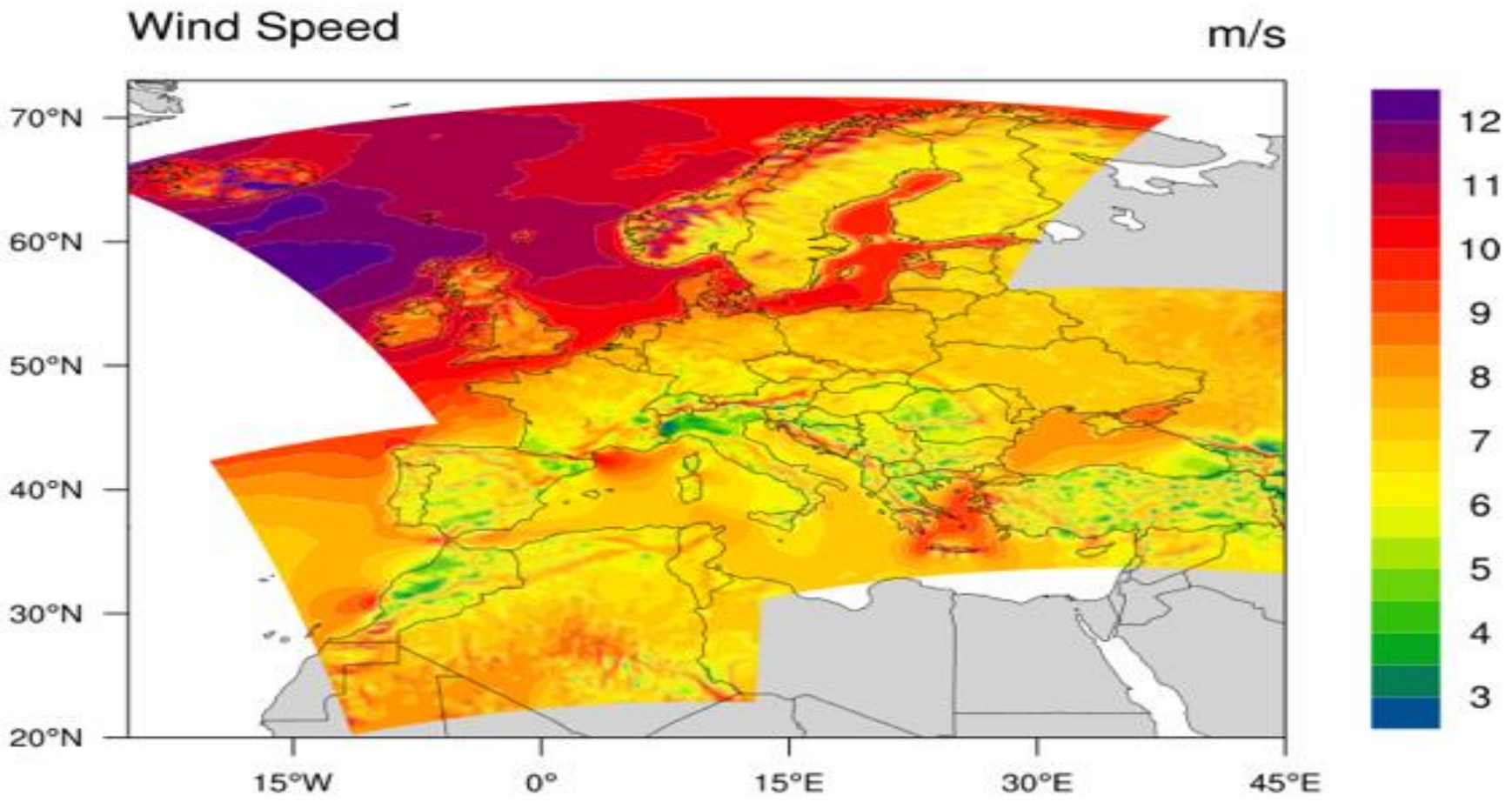
Accuracy of the SSM/I

The accuracy of the SSM/I series is now of a quality feasible for wind climate studies, i.e., changes in wind speed within 1% per decade can be assessed.

Hasager *et al. 2016* Remote Sens. 8, 769; doi:10.3390/rs8090769

WRF preliminary run for Europe

Wind speeds at 100 m, average 1982 to 2015

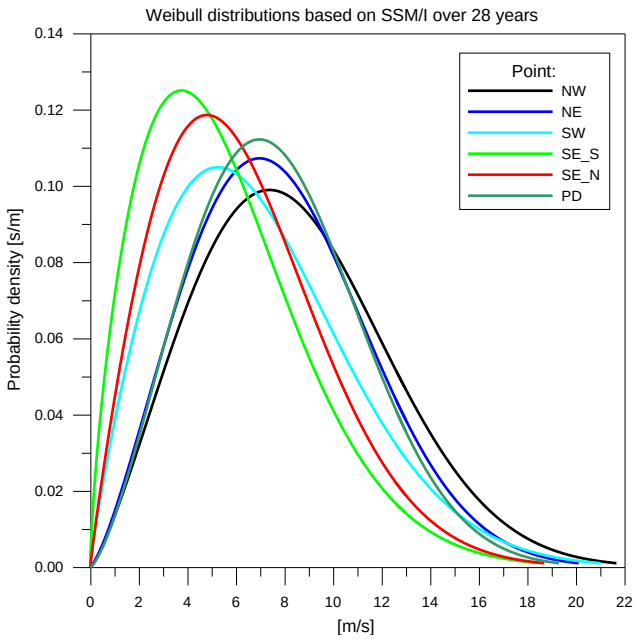


Comparison SSM/I and WRF stats

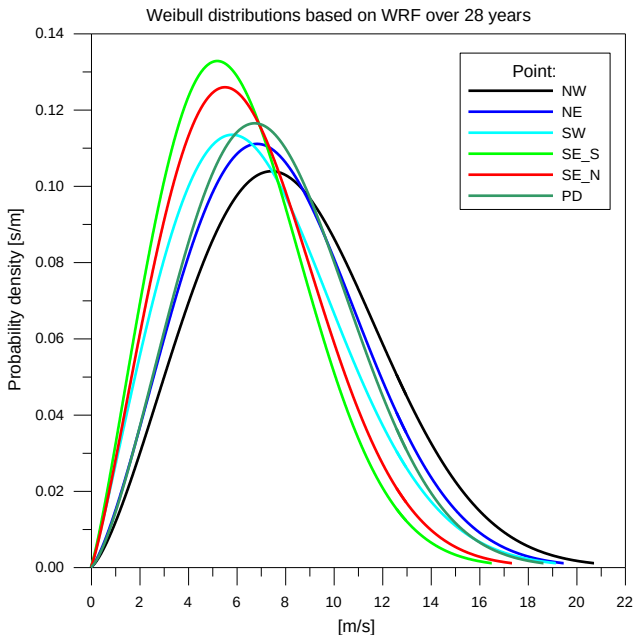
Table. Point coordinates and 28 year average of SSM/I and WRF wind speed data

Point name	Coordinates [deg]	Data count		Wind speed average		Weibull parameters			
		SSM/I	WRF	SSM/I [m/s]	WRF [m/s]	SSM/I k	SSM/I A	WRF k	WRF A
NW:	5E 56N	51556	245424	8.33	8.28	2.28	9.51	2.38	9.36
NE:	19E 56N	52116	245424	7.68	7.62	2.32	8.89	2.35	8.67
SW:	4W 45N	43059	245424	7.01	6.94	1.88	7.87	2.12	7.87
SE_S:	30E 35N	38136	244680	5.66	5.98	1.71	6.27	2.19	6.88
SE_N:	30E 43N	41372	244680	6.23	6.35	1.92	7.05	2.20	7.28
PD:	11W 41N	40295	245424	7.62	7.41	2.40	8.72	2.41	8.43

SSM/I and WRF Weibull distributions

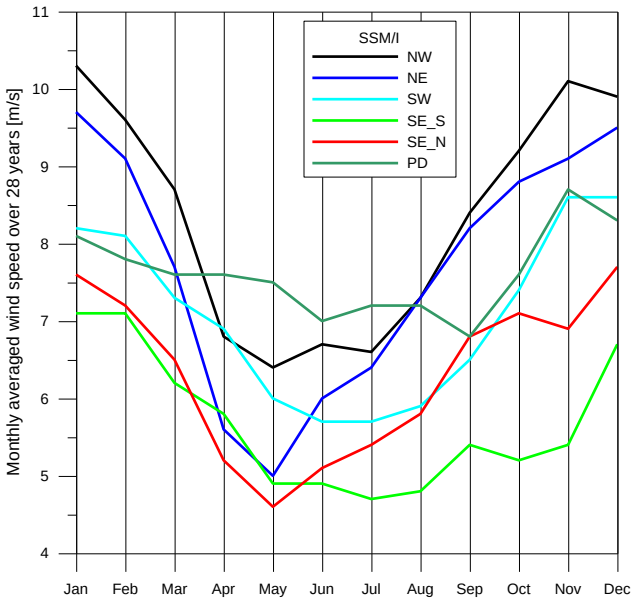


SSM/I

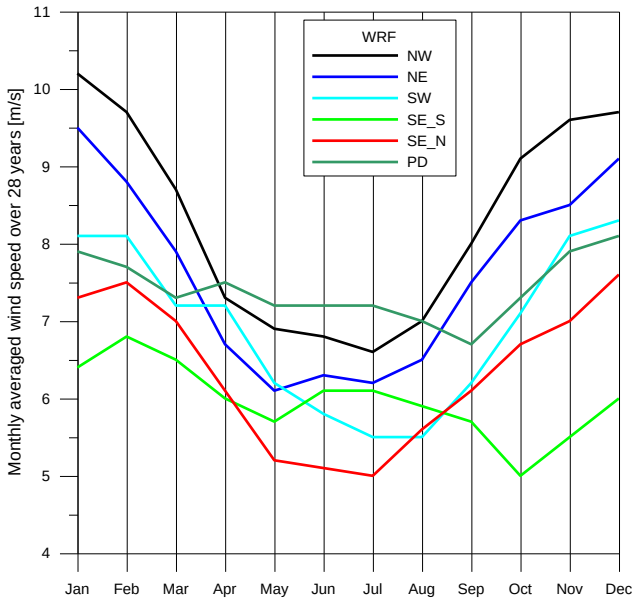


WRF

SSM/I and WRF annual averages

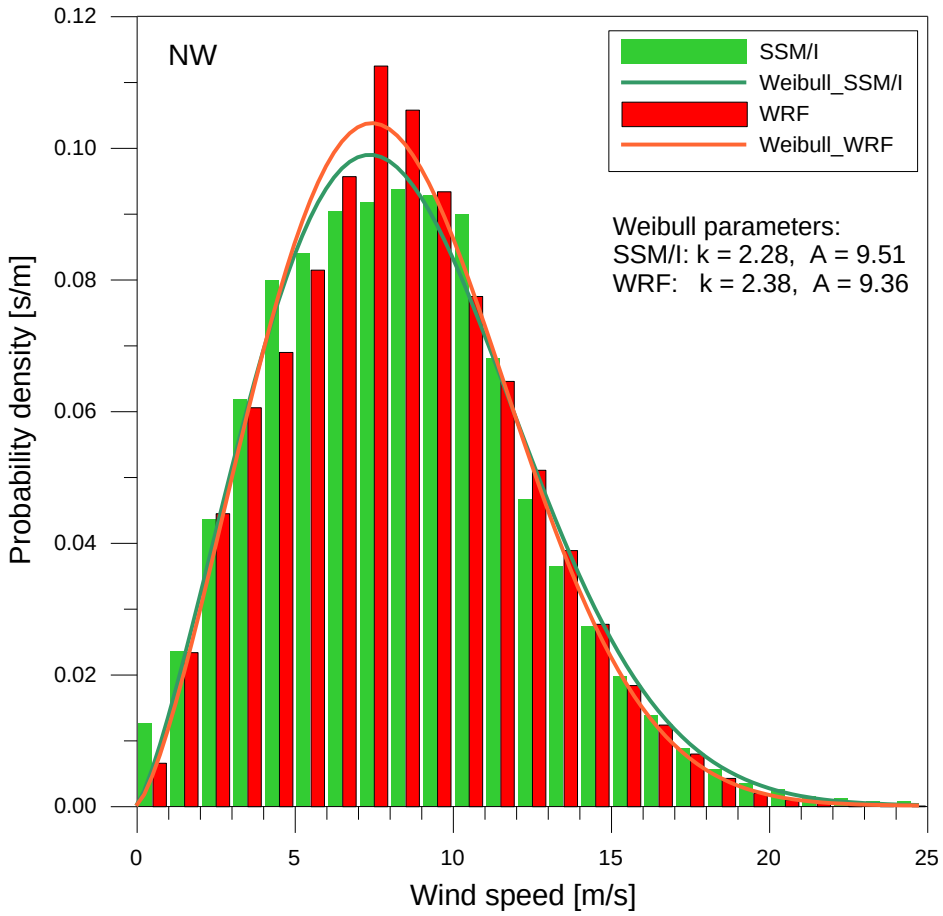


SSM/I

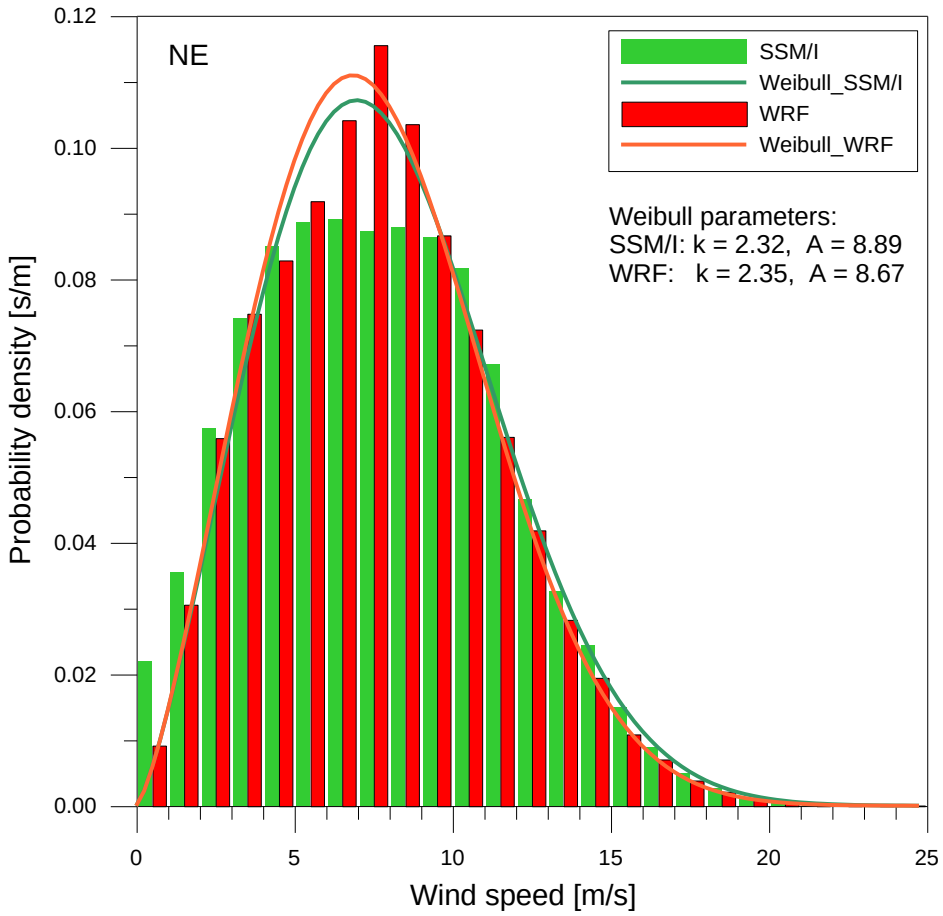


WRF

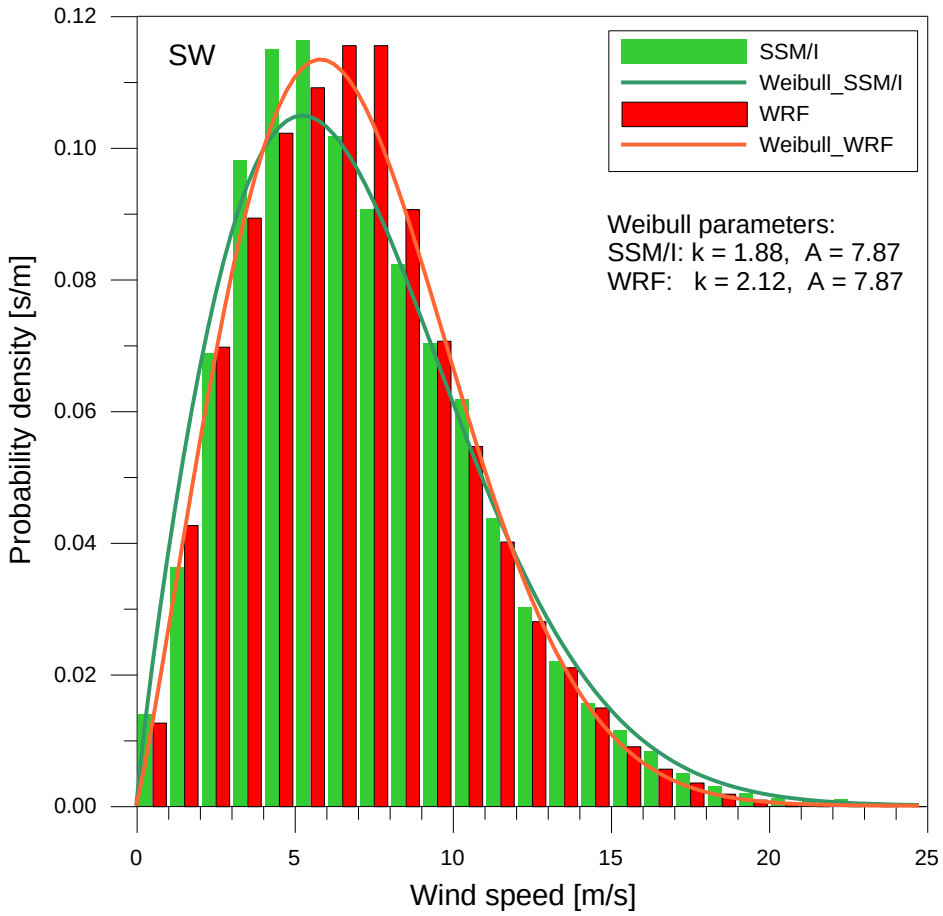
SSM/I and WRF (North Sea)



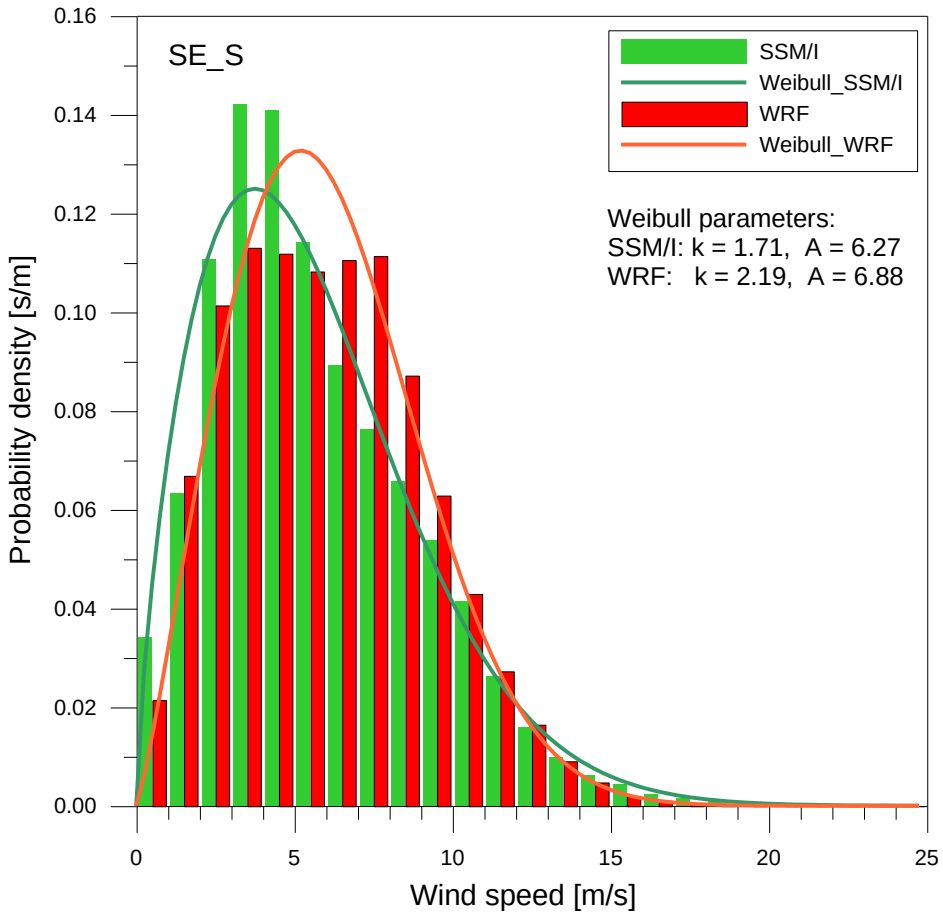
SSM/I and WRF (Baltic Sea)



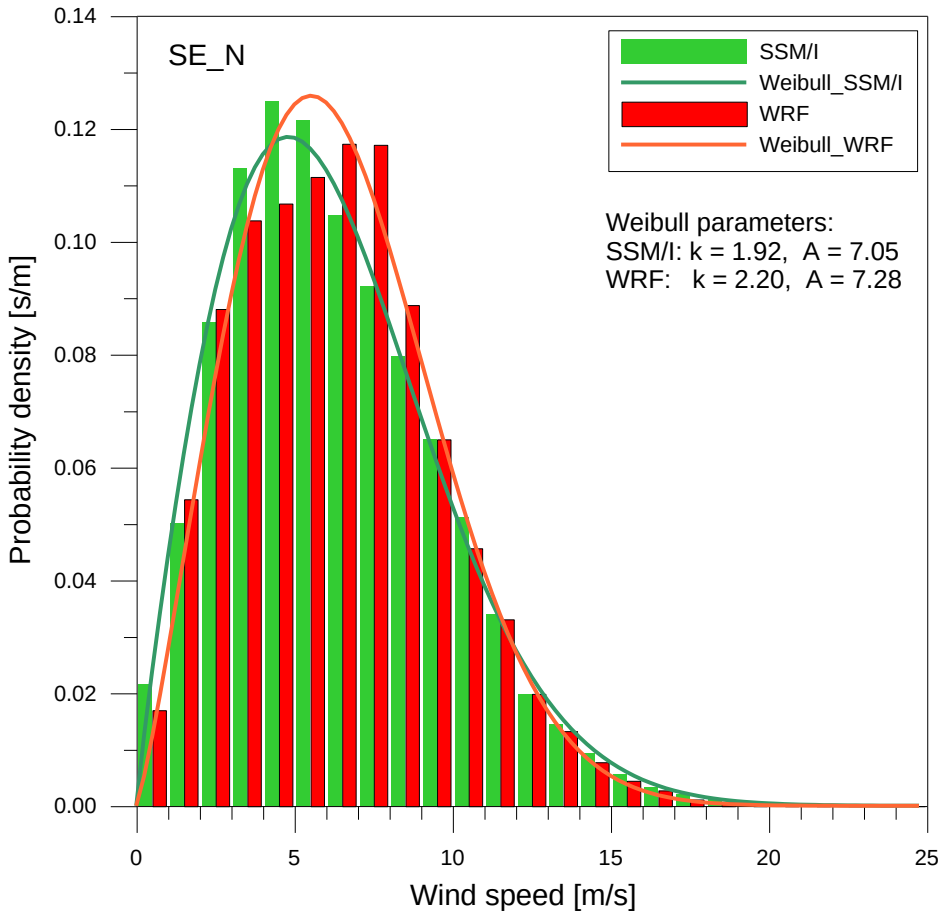
SSM/I and WRF (Atlantic Sea/Biscay)



SSM/I and WRF (Mediterranean Sea)



SSM/I and WRF (Black Sea)



Conclusions

- SAR provides **wind speed at** high spatial resolution (1 km by 1 km)
- ASCAT provides wind speed and wind direction (12.5 km by 12.5 km)
- SSM/I provides **wind speed at high frequency** during > 29 years (25 km by 25 km)

- Ocean wind retrievals offshore are valuable for:
  1) Model validation
  2) Offshore wind resource mapping
  3) SAR provides sufficient spatial resolution for the offshore wind atlas

- Limitations of satellite winds:
  Lack of information above the 10-m level above m.s.l.

- Lifting of winds to higher levels is necessary (Badger *et al.* 2016)

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